Chapter 6 Non-Structural Site Design Techniques

There are many non-structural site design techniques that can be used to reduce the volume of stormwater runoff generated at a site. Reduced volume means less stormwater requiring treatment before entering a receiving water. These techniques focus on maintaining and mimicking the natural hydrology to the maximum extent practical, minimizing land disturbance, and minimizing the amount of impervious cover.

Some of the techniques mentioned in this chapter may differ from some of the traditional site planning practices upon which local zoning requirements and subdivision standards have been based. As such, application of these techniques will need to be considered in the context of these local requirements. Where allowed by local requirements, the application of the techniques may be feasible with appropriate waivers or exceptions. In some cases, use of the techniques may require changes to zoning provisions or other local requirements.

6-1. Site Design Techniques

Traditionally, runoff management has focused on end-of-pipe methods to detain and treat stormwater. Although end-of-pipe methods have their place in stormwater management, when used alone they are often more costly and maintenance intensive than techniques that minimize stormwater runoff or treat it close to the source. Fortunately, there are many simple, non-structural methods that can be incorporated into the planning process that maintain the natural landscape and preserve the hydrologic functions of a site (U.S. Department of Housing and Urban Development, 2003). Applying such methods minimizes the amount of runoff generated and lessens the treatment volume by controlling stormwater at the source. This approach can also lower overall development costs by reducing the need for, and the sizing requirements of, structural, engineered devices. More information on the cost benefit of these site design

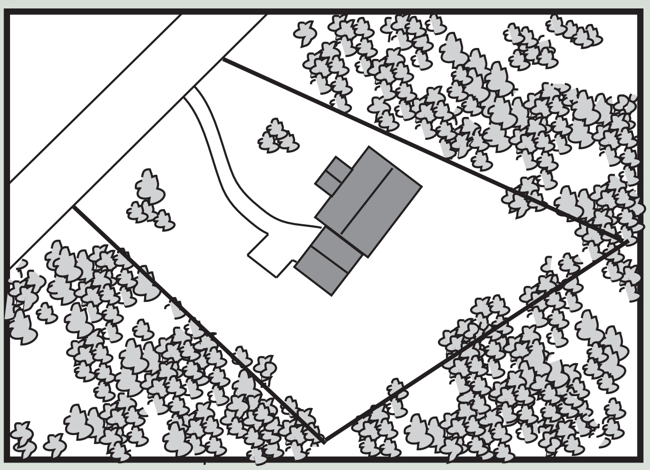

Figure 6-1. Property with maximum disturbance and nearly all of the vegetation removed.

techniques is available from the Low Impact Development Center at: http://www.lid-stormwater.net/background.htm

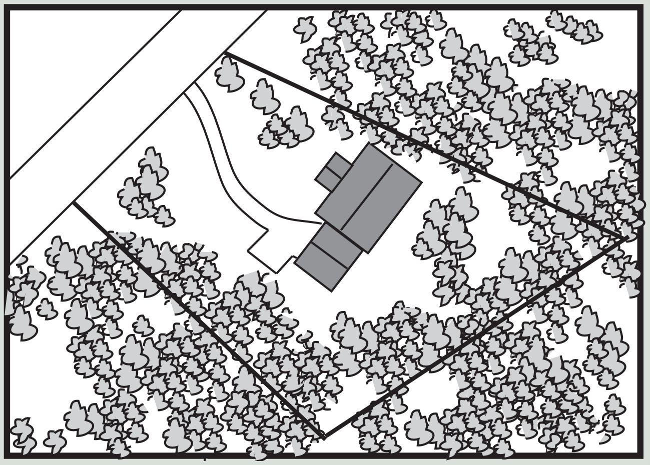

Figure 6-2. Property with vegetation selectively cleared to minimize disturbance.

In order to effectively incorporate these methods, the runoff from a site needs to be managed on a smaller scale. Accomplishing this often requires a shift in thinking. Instead of managing all of a site's runoff through one practice, e.g., collecting the runoff from a subdivision or a commercial development in one large stormwater pond, the runoff is addressed at the individual lot level through many different practices. For example, a site design might incorporate the use of rain barrels or dry wells to collect roof runoff, rain gardens to collect runoff from driveways or parking lots, and smaller stormwater ponds to collect runoff from common, open space areas. This design approach also requires a shift away from altering and grading a site to pipe runoff to a single discharge point, to instead, working with the existing topography and hydrology to maintain flow paths and maximize opportunities for natural flow attenuation and infiltration. This reduces the dependence of the development on downstream carrying and treatment capacity. The following site design concepts assist in reducing the amount of stormwater generated by managing stormwater at the source.

Minimize Disturbed Areas

Any change in the landscape from the existing condition is considered a disturbance. Disturbed areas include all impervious areas such as roads, sidewalks, and rooftops as well as pervious areas such as graded lawns and open drainage systems. The most effective way to minimize the amount of disturbed area and to reduce the stormwater impacts of a site is to use hydrology-based site design.

The primary function of hydrology-based site design is to work within the boundaries of the existing landscape. The first step is to identify existing natural features on the site to restrict and define site disturbance (Prince George's County, Maryland, 1999). For example, are there any steep slopes? Are there wetlands or streams? What are the soil conditions? Asking these questions and determining the most appropriate locations for disturbance and for preservation on the site is often referred to as "site fingerprinting".

Designers are encouraged to avoid disturbing sensitive areas, such as wetlands and streams and their buffer areas, flood plains, and steep slopes. It is also important to try to target disturbance to areas that already have a low capacity for infiltration, such as soils classified as hydrologic soil group C and D or other existing impervious areas. Once these areas have been identified it should be clearer where to locate the areas of disturbance on the site. Regulated resource areas such as wetlands should be clearly marked in the field for survey. All of these areas should be clearly identified on the base plans that the designer will use to develop the site plans for the project.

The following methods are examples of measures that can minimize the disturbed area on a site:

- Define the development envelope and clearly mark it on the plans and in the field.
- Use existing drainage divides by maintaining existing site topography.
- Avoid the removal of trees.
- Limit clearing and grading to the smallest amount required; disturbance should be limited to the building footprint, construction access and safety setbacks.
- Cluster vegetated areas and connect them with vegetated corridors.
- Cluster developed impervious areas and **disconnect** them (see explanation of "Disconnect Impervious Areas" below).
- Establish buffers to wetlands and streams.
- Conserve as much of the site in natural or existing vegetated condition as possible, or in re-development activities, reduce the amount of effective impervious cover by removing or replacing existing impervious cover and disconnecting it.

Maintain Natural Buffers

Maintaining natural buffers goes hand in hand with minimizing disturbed areas. Natural buffers around streams, wetlands, and other sensitive areas intercept runoff from pervious and impervious areas and treat it through natural filtration, infiltration, and vegetative uptake. The following criteria, adapted from the Center for Watershed Protection's "Site Design Credits", should be followed for a natural buffer to effectively treat stormwater.

- The minimum stream buffer width (i.e., perpendicular to the stream flow path) should be 50 feet as measured from the top of bank elevation of a stream or the boundary of a wetland;
- The stream buffer should meet the maintenance and design requirements of a local buffer ordinance, if applicable;

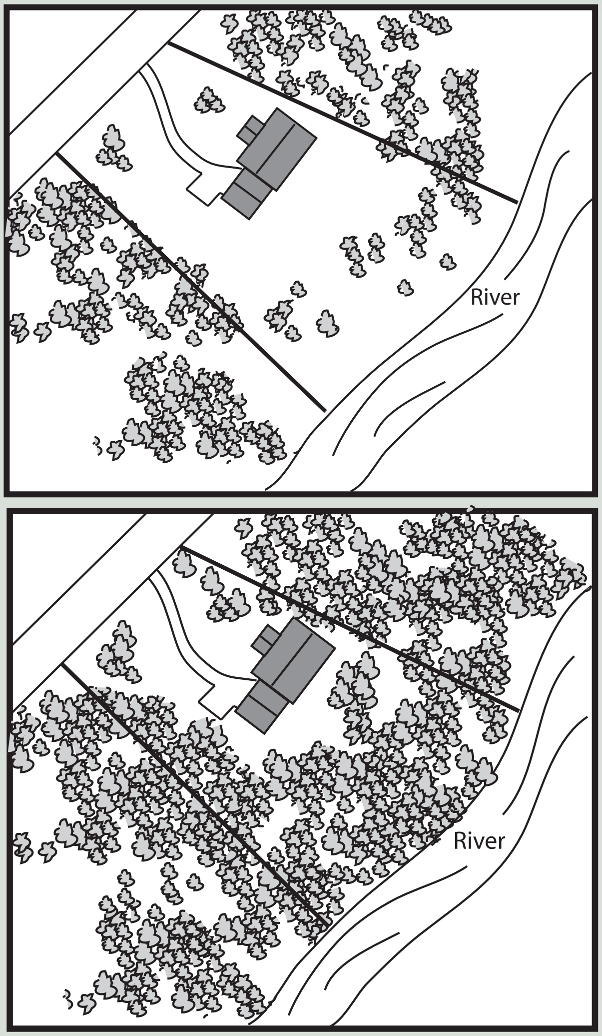

Figure 6-3. Comparison of a lot with very little natural buffer to one with a significant natural buffer intact.

- The maximum contributing flow path should be 150 feet for pervious surfaces and 75 feet for impervious surfaces;
- The average contributing overland slope to and across the stream buffer should be less than or equal to 5.0%;
- Runoff should enter the stream buffer as sheet flow. A stone level spreading device should be used where local site conditions prevent sheet flow from being maintained;
- The stream buffers should remain preserved by a conservation easement or similar protective mechanism. The ground surface must remain ungraded and uncompacted, and the over-story and under-story vegetation maintained in a natural condition.

Minimize Impervious Cover

Impervious cover includes areas such as sidewalks, driveways, roadways, parking areas and rooftops. In some cases, even lawn areas can be essentially impervious depending on construction practices and the extent to which the soils are compacted (USEPA, 2005).

Frequently, the highest percentage of impervious cover from a development site consists of the roadway. This is particularly the case in many residential subdivisions, and some commercial and industrial park areas.

Methods to minimize the impervious area associated with roadways include:

- Consider alternative roadway layouts.
- Employ narrower road widths.
- Use rural road design (“country drainage”) instead of curb, gutter, and piped roadway drainage (“closed drainage”).

- Limit sidewalks to only one side of the road, or consider pervious trails instead of sidewalks.
- Reduce the amount and type of on-street parking – only on one side, or parallel instead of diagonal.
- Incorporate porous or permeable pavement.

In commercial and industrial developments, as well as residential sites, rooftops, driveways, and parking areas also contribute to the total impervious cover. The following is a sample of methods that can be used to reduce impervious cover from these areas:

- Use a green roof .
- Build two story structures instead of single story structures, to maintain the square footage but reduce the building footprint.
- Use narrow driveway widths.
- Shorten driveway lengths, where grade allows.
- Use shared driveways.
- Use porous pavers or other pervious type of pavement for driveways, parking lots, and overflow parking areas.
- Reduce pavement within parking areas through careful design of efficient aisles and parking bays (e.g., parking on both sides versus one side of an aisle), coupled with the use of vegetated parking lot islands (instead of paved or gravel islands) with depressed planting beds to infiltrate runoff.

Disconnect Impervious Cover

Although the amount of impervious cover on a site can be minimized, it is unrealistic to think it can be eliminated completely. Despite this, impervious areas do not necessarily have to contribute to the runoff leaving the site. For example, by disconnecting the impervious areas and directing the flow to infiltration basins or designated buffer areas, a portion of additional runoff that would contribute to stormwater runoff is instead infiltrated close to the source. The runoff that would potentially carry pollutants from the site to a surface water instead gets treated and helps recharge groundwater. Disconnection methods and criteria are explained in Section 6-2 below.

Minimize Soil Compaction

As noted above, even lawns and gravel-surfaced areas can be essentially impervious. We typically think that the infiltration capacity of a lawn should be similar to that of a naturally vegetated area. This is not the case and is most often due to soil compaction during construction.

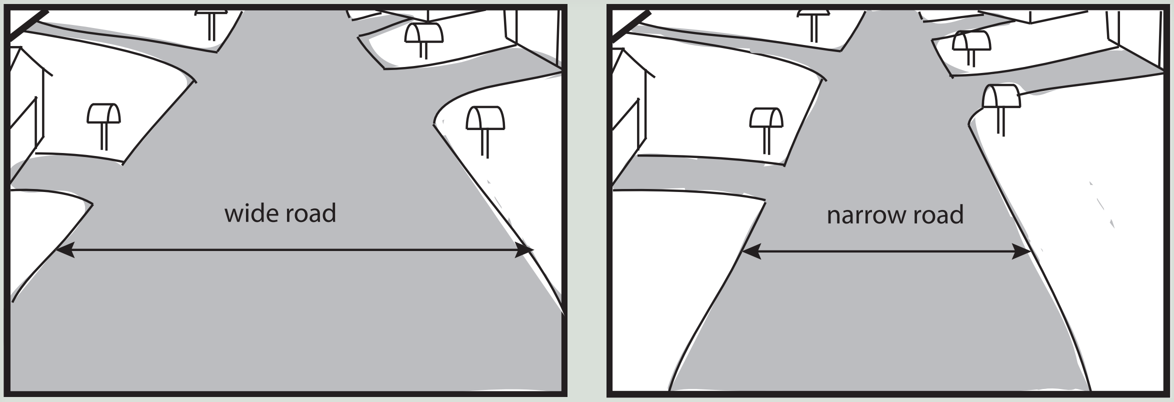

Figure 6-4. Reducing roadway widths can decrease impervious cover.

To reduce the potential for compacted soils, similar to minimizing impervious cover, the following methods can be used:

- Use site “fingerprinting” (discussed above) to determine the areas most appropriate for locating impervious cover.
- Limit development to soils with existing low infiltration capacity such as hydrologic soils group C and D soils (note, however, that some areas classified as D soils may be wetland resource areas or may have water tables at or near the surface and may not be suitable for development).
- Store machinery and equipment within the construction envelope to avoid unnecessarily disturbing areas that could remain vegetated.
- Store construction material and soil stockpiles within the construction envelope.
- Clearly mark on the plans and in the field the boundaries of disturbed areas.
- To the extent feasible, avoid repeated trafficking with construction equipment over areas that will be landscaped, and where construction traffic cannot be diverted, prior to final landscaping deeply scarify impacted soils to restore their infiltration capacity.
- If areas are proposed for use for infiltration of stormwater, then particular efforts will be required to avoid compaction of these areas by construction equipment or traffic, discharge of sediment laden waters to these areas during construction, and premature use of these areas for stormwater management prior to stabilization of these facilities and the contributing drainage areas.

Use Alternative Pavement

The largest portion of impervious cover in most developed areas is created by parking lots and roadways. It may not be feasible, at this stage in the development of alternative pavements, to use them on highways and heavily traveled secondary roadways. However, parking areas, including commercial parking lots and residential driveways, present an ideal opportunity for alternative pavements to reduce impervious cover. Alternative pavements can also be used on sidewalks, low-traffic alleys or side streets, and walking paths. They may also be used in overflow parking areas, rest areas, and park-and-ride lots. The most common alternative pavement materials are separated into two types: modular pavers and porous pavement.

Modular pavers consist of a solid, structural component such as brick, block, concrete, stone, or interlocking grid pavers separated by a pervious material such as sand, gravel, or sod. They are typically set on a sand or gravel base and are load bearing sufficiently to support vehicles. Porous pavements are either porous asphalt or porous concrete. Porous asphalt is similar to traditional asphalt with the exception that there are no fine aggregate materials. Instead only coarse aggregate is used, which creates voids in the material for water and air to easily pass. Similarly, porous concrete is a discontinuous mixture of Portland cement, coarse aggregate, admixtures, and water that result in voids where water and air can pass. Both porous asphalt and concrete are typically underlain by a reservoir comprised of coarse aggregate (such as uniformly graded stone). Further information on the design of these systems can be found in the New Hampshire Stormwater Manual Volume 2: Post-Construction Best Management Practices Selection and Design.

Using these alternatives to traditional asphalt pavement reduces the overall impervious cover of a site and can also act as a mechanism to disconnect other impervious areas. It can reduce the need for conventional stormwater management facilities as more water is infiltrated and the volume of water to be treated through detention or retention is reduced. Research conducted by the University of New Hampshire's Stormwater Center has also found that porous pavement can reduce the amount of salt needed for deicing road and parking area surfaces, and reduces the formation of black ice due to less pooling of water on the pavement surface.

There may be a number of barriers to using alternative pavement. The most common barrier seems to be the misconceptions in regard to maintenance, long term effectiveness, and use in cold climates. These misconceptions are summarized in Table 6-1. An additional barrier may be that a municipality's zoning ordinance or subdivision regulations do not allow for alternative pavement. Overcoming these barriers can be accomplished through education, observation of example projects in other locations, and local demonstration projects, as well as revisions to local land use regulations. More information on porous pavement can be found at the University of New Hampshire's Stormwater Center website at: http://www.unh.edu/erg/cstev/

Table 6-1. Misconceptions & Truths about Porous Pavement Compared to Traditional Pavement

Misconception	Truth
Freezes faster	Has demonstrated increased speed in thawing due to flow through by meltwater
Higher maintenance and cost	Overall costs are comparable
Slippery	Developed to have higher friction than traditional asphalt
Cannot plow, salt, or de-ice	Can be plowed and de-iced, however salt brine solutions are recommended over road salt application
Heaving and shifting	Reduced compared to traditional asphalt due to vadose zone disconnect
Lower life span	Actually increased life span due to reduced freeze thaw

Source: University of New Hampshire Stormwater Center.

6-2. Impervious Surface Disconnection Methods

The amount of runoff and associated pollutants from a project can be reduced by disconnecting impervious surfaces. These disconnection methods are non-structural stormwater management practices focused on infiltrating stormwater. They are based on the "Site Design Credits" developed by the Center for Watershed Protection. By implementing the disconnection methods according to the criteria described here, a project can more easily meet the effective impervious cover targets described in Section 5-2. In addition, well-conceived use of disconnection methods can reduce overall project costs by reducing or eliminating the need for more expensive structural practices.

Disconnection methods should be incorporated at the planning and design level. However, the designer and reviewer should note that these methods must be used in concert with the design of other stormwater conveyance and treatment practices. The use of these disconnection methods does not relieve the designer or reviewer from following the standard engineering practices associated with safe conveyance of stormwater runoff and good drainage design. The nonstructural disconnection methods are presented in this manual under two categories:

- Disconnection of Rooftop Runoff
- Disconnection of Non-Rooftop Runoff

The minimum criteria that must be met in order to be considered sufficiently disconnected and eligible to omit the disconnected impervious areas from the Effective Impervious Cover (EIC) of the site (see discussion in Chapter 5) are described below.

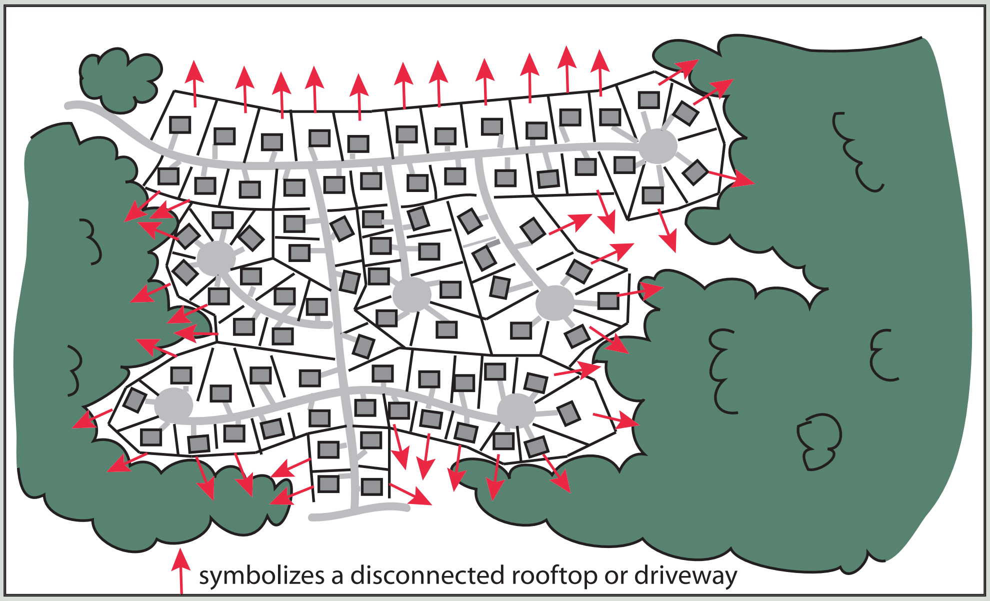

Figure 6-5. The amount of runoff and associated pollutants from a project can be reduced by disconnecting impervious surfaces through the disconnection methods described in Section 6-2.

Disconnection of Rooftop Runoff

The impervious area associated with a rooftop can be omitted from the impervious cover of a site when the rooftop runoff is "disconnected" and then directed to an area where it can infiltrate the soil or flow over a pervious area such as a lawn or a swale with sufficient time and velocity to allow for filtering. This is typically accomplished by grading an area of the site, if natural slopes are not suitable, to promote overland flow through a vegetated buffer, or by directing the flow to an infiltration practice.

If a rooftop is adequately disconnected, the disconnected impervious area can be deducted from the total site impervious cover. Disconnections of rooftop runoff must meet the following criteria:

Criteria:
The disconnection must be designed to ensure no basement seepage or connection to foundation drains;

- The contributing rooftop length should be 75 feet or less;
- The rooftop contributing area to any one discharge location cannot exceed 1,000 square feet;
- The length of the "disconnection" flow path over the pervious area should be equal to or greater than the contributing rooftop length;

- Credit for disconnections will only be given for lot sizes greater than 6,000 square feet unless management practices include dry wells, infiltration trenches or basins, or equivalent infiltration practices;

Example Disconnection of Rooftop Runoff Calculation

<u>Scenario</u>

Site Data: 54 Single Family Residential Lots
(~ ½ acre lots)
Site Area: 27 acres
Total Impervious Cover (TIC): 6 acres
Number of disconnected rooftops: 20
Average house area: 2,500 ft^2
Conversion factor (ft2 to acres): 43,560 ft^2/acre

<u>Calculation</u>

Disconnected Area (AD)
= (# Disconnected rooftops) * (Average house area)
= (20) * (2,500 ft^2)
= 50,000 ft^2
= 1.15 acres

Effective Impervious Cover (EIC)
= TIC - AD
= (6 acres) – (1.15 acres) = **4.85 acres**

- The disconnection flow path length should be only that which drains continuously through a vegetated channel, swale, or through a filter strip to the property line or a stormwater treatment practice;
- The entire vegetative “disconnection” should be on a slope less than or equal to 5.0%;
- Downspouts must be at least 10 feet away from the nearest impervious surface to discourage re-connection to the drainage network;
- Disconnections are encouraged on relatively permeable soils (USDA Hydrologic Soil Groups A and B);
- For rooftop disconnection in a designated high load land use, the rooftop must not commingle with runoff from any paved surfaces.

Disconnection of Non-Rooftop Runoff

Non-rooftop impervious surfaces associated with site development, such as driveways or parking areas, can be omitted from the impervious cover of a site, when the impervious surfaces are directed to an area where runoff can infiltrate into the soil or is allowed to flow over a pervious area such as a lawn or swale that provides sufficient time and slows the flow of water enough to allow for filtering or infiltration.

If impervious areas are adequately disconnected, the disconnected areas can be deducted from the total site impervious cover. Disconnections of non-rooftop runoff must meet the following criteria:

Criteria:

- The maximum contributing impervious flow path length should be 75 feet;
- Runoff cannot come from a designated hotspot land use;

- The disconnection must drain continuously through a vegetated channel, swale, or filter strip to the property line or a stormwater treatment practice;
- The length of the "disconnection" flow path over pervious surface must be equal to or greater than the contributing length;
- The entire vegetative "disconnection" should be on a slope less than or equal to 5.0%;
- The area of impervious surface contributing to any one discharge location cannot exceed 1,000 ft2;
- Disconnections are encouraged on relatively permeable soils (HSGs A and B).

Example Disconnection of Non-Rooftop Runoff Calculation

Scenario

Site Data: 54 Single Family Residential Lots
(~½ acre lots)
Site Area: 27 acres
Total Impervious Cover (TIC): 6 acres
Number of disconnected driveways: 32
(avg. length 100 ft)
Driveway width: ~10 ft
Total disconnected driveway length: 3,200 ft
Conversion factor ft2 to acres: 43,560 ft^2/acre

Calculation

Disconnected Area (AD)
= (driveway width) (total disconnected driveway length)
= (10ft) (3,200 ft)
= 32,000 ft^2
= 0.73 acres

Effective Impervious Cover (EIC) = TIC - AD
= (6 acres) – (0.73 acres) = 5.27 acres

Chapter 6 References

Ballestero, Thomas, PhD. "Stormwater: Pariah, Concern, Facts, and Fiction." 2006. University of New Hampshire. 7 July 2006. http://www.unh.edu/erg/cstev/ Presentations/ri_asce.pdf

Center for Watershed Protection. Better Site Design: A Handbook for Changing Development Rules in Your Community. August 1998.

Center for Watershed Protection. "Stormwater Credits." A Stormwater Design Manual Toolbox. 2006. 24 Feb 2006. http://www.stormwatercenter.net/ Manual_Builder/Credits/Credits%20Intro.htm.

Comprehensive Environmental Inc. City of Nashua, New Hampshire Alternative Stormwater Management Methods Part 1. Planning and Guidance. March 2003.

Horsley Witten Group. Model Stormwater Regulations; Duxbury, Marshfield, and Plymouth, MA. December 31, 2004.

Maine Department of Environmental Protection. *Stormwater Management for Maine.* No. DEPLW0738. January 2006.

Prince George's County, Maryland Department of Environmental Resources, Programs and Planning Division. *Low Impact Design Strategies: An Integrated Design Approach.* January 2000.

United States Department of Housing and Urban Development. *The Practice of Low Impact Development.* July 2003.

United States Environmental Protection Agency. *National Management Measures to Control Nonpoint Source Pollution from Urban Areas.* 2005

University of New Hampshire Stormwater Center. *2005 Data Report.* 2005.